

# Light Threads – Illustrating Movement Dynamics in City Models (sap\_0165)

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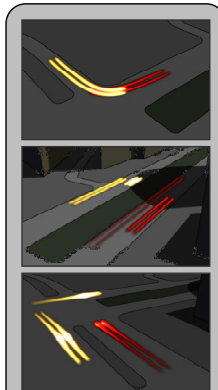


Figure 1: Direction of motion, velocity, and acceleration.

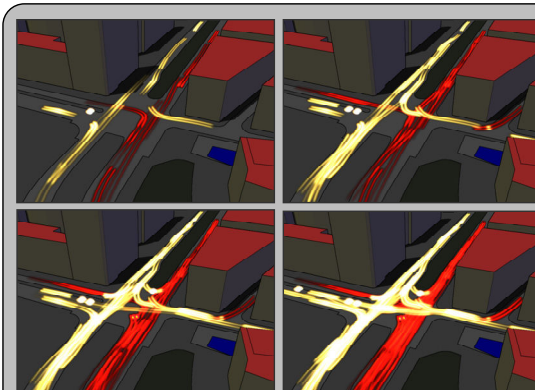


Figure 2: The accumulation of light threads illustrates the flow and the density of traffic.

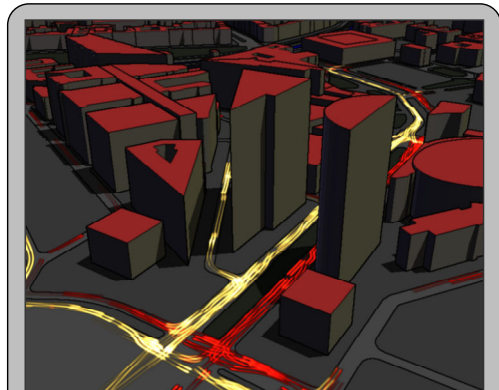


Figure 3: The illustrative map enables experiential cognition of dynamics in a static image.

## Introduction

Visual representations of traffic flow and density in 3D city models provide substantial decision support in urban planning. While a large repertoire of efficient techniques exists for visualizing the static components of such environments (e.g., digital terrain models, building models, and vegetation), less is known about illustrating their dynamics nature.

We present *light threads*, a novel method that represents vehicle behavior for illustrating the traffic in urban space. The generated illustrative maps turn humans' cognition of vehicular behavior from a reflective into an experiential mode (Norman 1993). Light threads are a familiar visual metaphor caused by moving light sources producing streaks in a long-exposure photograph. A vehicle's front and rear lights produce light threads that convey its direction of motion as well as its velocity and acceleration. The accumulation of light threads allows a viewer to quickly perceive traffic flow and density. The light-thread technique is a key element to effective illustrative maps supporting analytic reasoning, exploration, and monitoring of geospatial processes.

## Illustrative 3D City Representations

Illustrative 3D city maps (Döllner et al. 2005) are visual representations of 3D city models complementary to Virtual Reality visualizations. They accomplish the following:

- Emphasizing high perceptual and cognitive quality to effectively communicate contents, structure, and relationships of urban objects and their related thematic information while reducing distracting details.
- Enabling a fully automated generation even in the case of scarce urban spatial information since high-quality and complete data is rarely available for large-scale urban areas.
- Enabling the exploration and visual analysis even on small display devices.

Applications of illustrative 3D city models are primarily all of the various visual interfaces to urban spatial information required, e.g., in city development planning or city information systems.

## Light Threads

Light threads represent a visual metaphor for depicting the motion of a single vehicle in a static image. Conceptually, light threads are dynamics glyphs that reproduce the vast streaks and the highlights that appear in long-exposure photographs when capturing moving light sources. Brighter highlights and vaster

streaks appear for slow motions which lead to overexposed selective highlights, e.g., for resting light sources. Weaker highlights and thinner streaks appear for fast motions. If the velocity of the motion changes the tintorial strength and the width of the streak vary accordingly. We implement light threads to illustrate the time-variant paths of every vehicle in urban space in a certain time interval. Figure 1 shows light threads that communicate the vehicles' direction of motion, velocity, and acceleration comprehensively.

## Traffic Flow and Density

At a microscopic level of abstraction, we combine the light thread of every vehicle's dynamics. Accumulating them in a single image produces bright highlights where light threads overlap and thicker light threads where vehicles follow approximately the same motion path, though temporally deferred. For instance, vehicles heading in one direction following a road produce overexposed highlights and their intermixing light threads provide a streamlines-like appearance. Consequently, the accumulation of light threads encodes the traffic flow and density in urban space (Fig. 2).

## Urban Transportation Planning

City planners evaluate urban transportation models. Illustrations of movement dynamics provide a direct visual interface to complex traffic data. Light threads generate *traffic maps* that enable humans to gain a rapid overview of various scenarios (Fig. 3).

## Real-Time Systems for Congestion-Awareness

Combining real-time systems for monitoring traffic flow and density (e.g., by tracing cell phones) with light threads generate *mobile maps*, which can be broadcasted to mobile devices such as cell phones, PDAs, or navigation systems to provide effective on-board information for efficient decision-making.

## References

- DÖLLNER, J., BUCHHOLZ, H., NIENHAUS, M., AND KIRSCH, F. 2005. Illustrative Visualization of 3D City Models, *Proceedings of VDA 2005*.  
NORMAN, D. A., 1993. *Things That Make Us Smart – Defending Human Attributes in the Age of the Machine*, Basic Books, New York.

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